Fabricating Microheaters to Test Thermoluminescence in Nanoparticles

Final UROP Summary

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The goal of the initial proposal involved testing for thermoluminescence in different nanoparticles at high temperatures such as explosions or events of high heat. Thermoluminescence is a process that is similar to the the release of photons in molecules where electrons make a jump in an energy level that corresponds to an energy level in the visible light spectrum. The difference here involves phonons and electron traps in the various nanoparticles to be used.

In order to expose these nanoparticles to such high temperatures, a method was developed using fabricated microheaters. These microheaters are grown on silicon wafers and designed in such a way that would conduct current and raise the temperature in its vicinity where the nanoparticles would be placed.

During the time that I began my UROP with the intent of testing various nanoparticles, the microheaters were not yet fully developed and have had some complications in its fabrication. With the microheaters being a key component for my initial proposal, I refocused with the advice of my mentor to help in the developmental process.

As stated before, the microheaters were fabricated on a silicon wafer with the help of the clean room in the Minnesota Nano Center. At the time, we began by first depositing a 100nm layer of HfO_2. After an application of the necessary resists and proper mask, through a lift-off process, tungsten was then deposited. The tungsten was deposited in such a way that it snaked around the microheater in one of two layouts. The first left an empty space at its center and the second covered the entirety of the microheater platform as seen in figure 1. The tungsten is the conductor that will then act as the heating element. The next few steps then involved releasing the microheater in such a way that it is suspended as much as possible from the rest of the silicon wafer. This is done through a deep trench etching process from the underside of the silicon wafer. This reduced thermal conduction from the microheater. There are legs that then hold the platform of the microheater up at each corner of the square arrangement with gold contacts near the ends of the tungsten. Many microheaters were made in this process that ranged from 300-600μm.

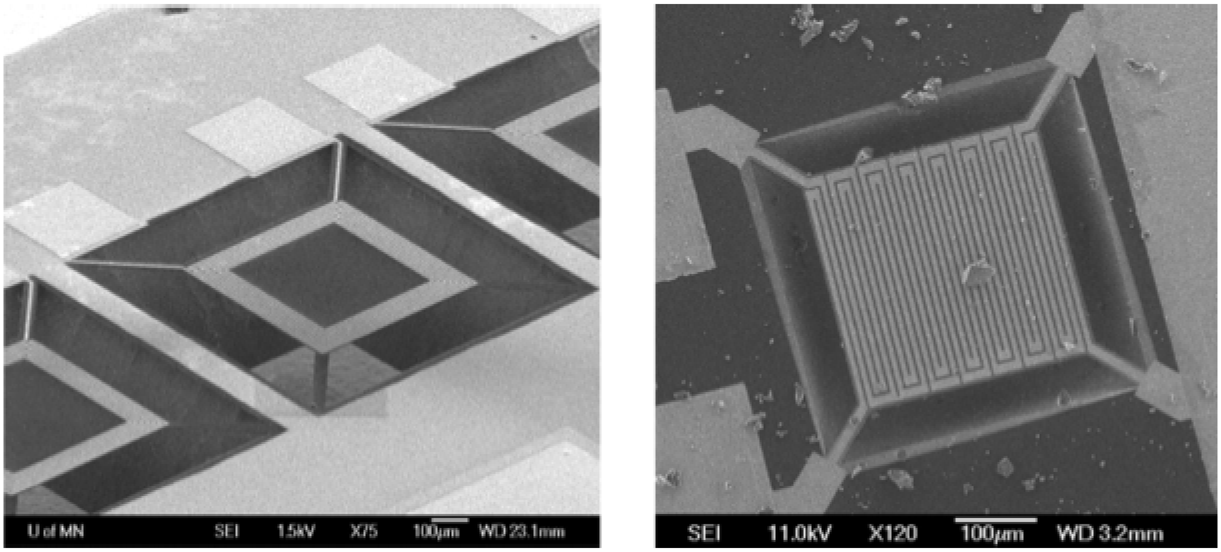

Figure 1: Two images of the microheaters fabricated. Left image, the tungsten wraps around the center creating a space with no conductor. Right image, the tungsten snakes around the entire platform of the microheater.

After a few trial runs of the microheaters, we found that they were unreliable in a number of ways. The first being the thickness of the legs that held the platform. The legs were either too weak to hold the platforms up at such high temperatures or too thick and too much heat escaped and flowed out into the silicon wafer. To resolve this, different thicknesses of the legs were fabricated with hopes of finding the ideal thickness with little success.

Another issue that was proposed was the material that was being used. HfO_2 is a very stressy material and being cut away from the silicon substrate weakened the legs further. A proposed solution would be to use different material to deposit initially that may be less stressful at small scales.

I ended my UROP at this point. The fabrication of the microheaters continued under the graduate student that I worked with and he continued to implement the solutions suggested. My overall UROP experience taught me the importance of the amount of time involved in research in order to obtain desired results. Complications arise and must be addressed in the best possible way. I have not done what was initially in my proposal, however, I feel that I have gained vital experience and exposure to what research looks like outside of just the classroom.